

MAJOR PREGLACIAL, NEBRASKAN AND KANSAN GLACIAL DRAINAGES IN OHIO, INDIANA, AND ILLINOIS

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The drainage as it exists today in the area under consideration has been brought about through various agencies and processes which worked on the underlying rock material over long intervals of geological time. The character, elevation, and slope of the surface rock formations, and especially the advance southward from Canada of the different glaciations over most of the northern part of the United States, have been the most important factors in determining the drainage.

Underlying Rock Formations

The different rock formations as they appear at the surface in the three states herein considered are outlined in figure 1 and are taken from state geological maps. They are known as the Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian and Permian systems.

The material composing the different geological systems was originally deposited in shallow seas in the form of sand, silt, clay, and calcareous ooze and later was consolidated into sandstones, shales, and limestones; and during the formation of the Appalachian Mountains, it was uplifted and tilted so that today, in most of the area under consideration, the formations are no longer horizontal, but in certain areas they have been arched upward into anticlines. This increased the erosion, so that in some areas the younger formations have been removed and the older ones, generally more easily eroded, now constitute the surface at practically the same elevations, or even a higher one than some sections of the younger formations.

Such an arch, including the Ordovician, Silurian, and Devonian formations, sometimes referred to as the Cincinnati anticline, extends northward from Kentucky through southwestern Ohio and southeastern Indiana and divides, one section turning northeastward through Lake Erie and also northwestward around Lake Huron and the other section turning northwestward through northern Indiana and Illinois and then northward around Lake Michigan to unite with the Lake Huron section, thus surrounding the younger geological formations in the southern Michigan peninsula.

A fault extends northwestward across northern Illinois. North of this fault line the older geological formations, principally Ordovician and Silurian, constitute the bedrock surface while south the younger formations, principally Mississippian, form the surface.

A narrow band, known as the LaSalle anticlinal belt, along which the rock formations have been warped upward, extends southeastward from Ogle County in northern Illinois to Wabash County, but the older geological formations reach the rock surface in only a few small areas along this belt.

The elevations of the different formations gradually decrease at approximately right angles to the direction of the anticlinal axes and the rate of erosion also decreases, so that the younger formations (fig. 1) successively constitute the surface, except in some areas where streams have formed deep, and in some sections broad, valleys, in which the older formations form the bedrock surface. The younger formations constitute the bedrock surface in practically all the eastern half of Ohio, except the extreme northern part and also the southwestern part of Indiana and practically all of Illinois, except the northern part.

Of the older formations the Devonian was probably the most easily eroded

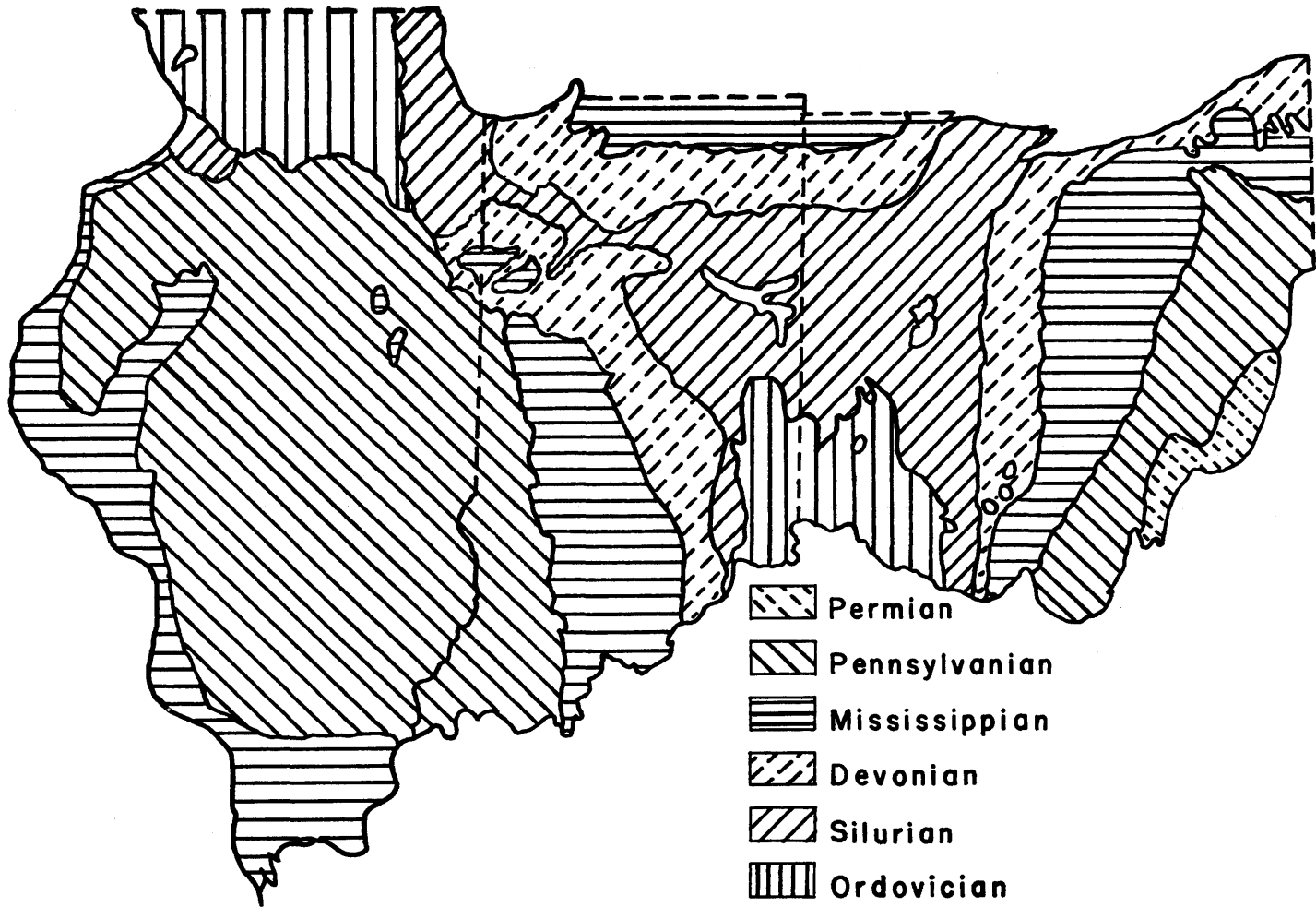


FIGURE 1. Geological map of Ohio, Indiana, and Illinois.

and this resulted in the formation of the broad Scioto Valley, which extends northward from the Ohio River through central Ohio to the Lake Erie plains. In Indiana a rather similar broad valley, known as the Scottsburgh lowland, extends northwestward from the Ohio River near New Albany, through this lowland, which is likewise underlain by the Devonian formation and in northwestern Indiana almost connects with another section, which extends eastward from Lake Michigan across northern Indiana and northwestern Ohio to Lake Erie. In Illinois the Devonian formation was evidently removed in the area north of the fault line except a small area near the Indiana line.

Elevation of Bedrock Surface

The present elevation of the bedrock surface furnishes some of the most important evidence in considering the location of the preglacial drainage and the changes that were brought about by the advance of the different glaciations. Contour maps of the bedrock surface have been made covering most of the three states considered, except the southeastern part of Ohio; but the contour intervals are not the same, making it somewhat difficult to adjust the contours along the boundary between the states. On maps for Ohio by Stout (1943) and Cummings (1959), the contour intervals are 100 ft; for Indiana (Wayne, 1956), 250 ft; and for Illinois (Horberg, 1950), 50 ft. A map, compiled from these state maps, is shown in figure 2. On it are roughly indicated the 1000-ft contours in Ohio and a few small areas in Indiana, the 750-ft contours in Indiana and the 600- and 700-ft contours in Illinois. The areas surrounded by the contours have an elevation higher than that indicated on the contours, and those not so included usually have a lower elevation.

The contours on the bedrock surface maps indicate that the highest elevations are in Ohio, where the divides and many small areas in the north and east central and northeastern parts of the state are above 1200 ft, with the highest elevation, near Bellefontaine in Logan County, over 1300 ft. The elevation in northwestern Ohio, along Lake Erie and the larger valleys, is less than 800 ft. In the lower Maumee and Sandusky river valleys and extending as a narrow strip eastward along Lake Erie and also along the Scioto, old Mahomet, Miami and Ohio Rivers and some other streams, the bedrock surface elevation is below 600 ft or near the level of Lake Erie, which is 573 ft.

There are only a few small areas in Indiana where the bedrock surface is above 1,000 ft. The largest one extends north from the Ohio River west of New Albany and is a part of the Norman upland. Three others are in the east central section and one is in the southeastern part. Most of the southeastern part of the state, except the Scottsburgh lowland, which extends northward from the Ohio River at New Albany, is above 750 ft, while the remainder is below 750 ft. The southwestern part, the old Mahomet Valley, a small area in the northeast part and also one bordering Lake Michigan are below 500 ft.

The section of Ohio and Indiana with higher bedrock elevations, often referred to as an extension of the Appalachian Plateau, or the Lexington Peneplain, extends northward in eastern Ohio almost to Lake Erie and from there its northward boundary is southwestward through central Crawford County, northern Logan and Drake Counties and continues southwestward and includes most of southeastern Indiana, but is intersected by the broad Scioto and Miami valleys in Ohio and the Scottsburgh lowland in Indiana. As the bedrock elevation north of this plateau decreases northward toward Lake Erie and Lake Michigan, it would seem to indicate that the preglacial drainage in Ohio and most of Indiana, except the southwest part, was northward into the lake basins.

Most of the northern and western parts of Illinois are above 600 ft and a considerable proportion are above 700 ft. In the extreme northwestern part of the state much of the area is above 800 or 900 ft and a few small areas are above

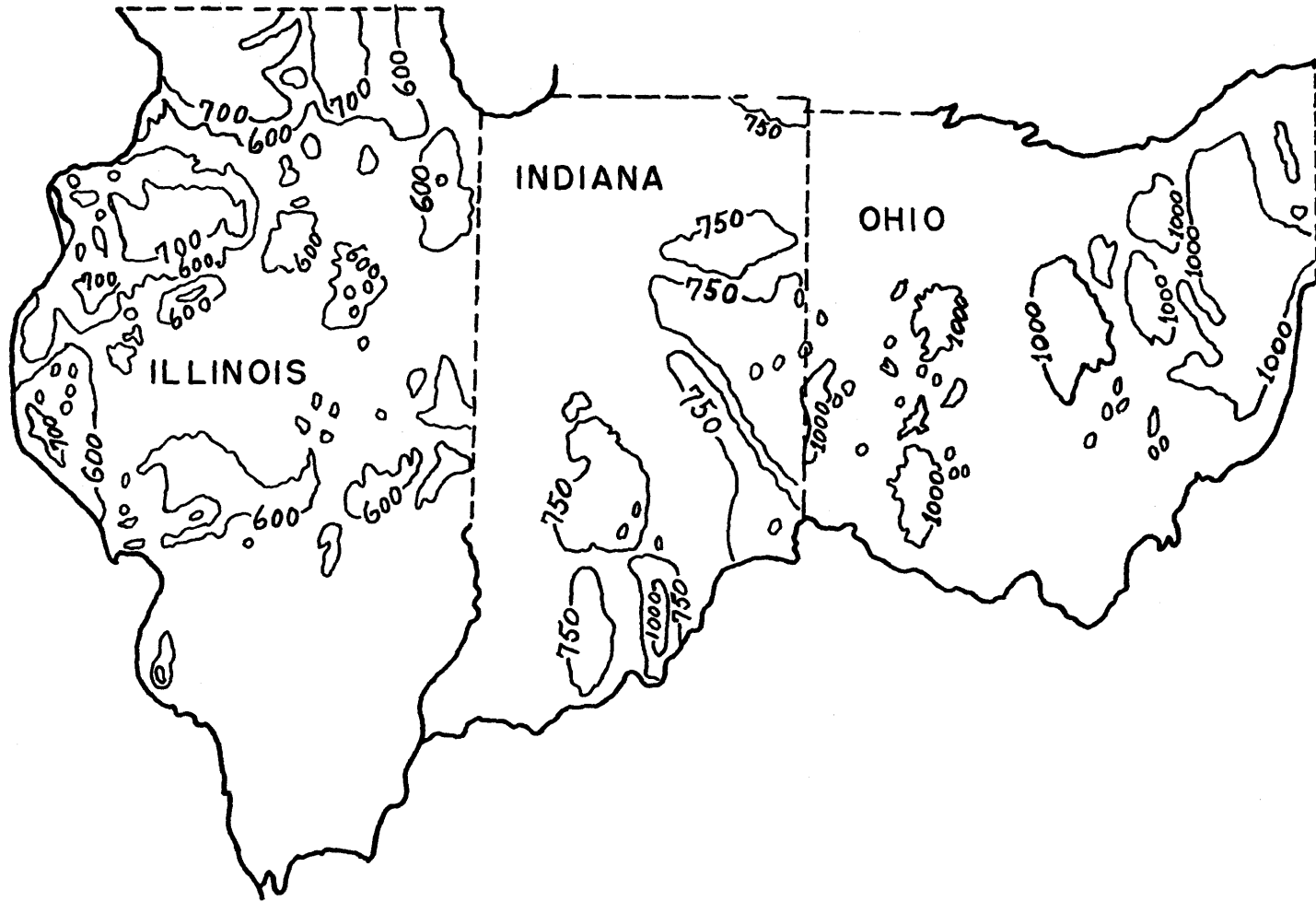


FIGURE 2. Contour map showing elevations of bedrock surfaces in Ohio (1000 ft), Indiana (750 ft), and Illinois (600 and 700 ft).

1,000 ft. Along the Indiana line in east central Illinois and extending south and then west across the south central part of the state to the Mississippi River, almost all the elevation is above 600 ft, except where it is intersected by the deep narrow valley of the Illinois River and in a few places by other small valleys. It may be possible that in preglacial time the elevation of the bedrock surface in practically all of Illinois north of this divide was more than 600 ft. In most of the central and southern part and a strip along Lake Michigan, the bedrock surface is less than 600 ft. Along the old Mahomet and present Illinois River valleys and their principal tributaries, and also in most of southern Illinois and in small areas along Lake Michigan, the bedrock surface is less than 500 ft; and along the center of the main valleys, including the old Mahomet River, it is less than 300 ft.

Preglacial Drainage

The first preglacial drainage systems were determined by the shapes of the newly emerged lands. But as the elevation and slope of the surface became greater in some sections than in others and rocks of various resistance were exposed, new systems with some large streams and broad valleys were developed; but the advance of the different glaciations, especially the earlier ones, brought about so many reversals and other changes in the streams and the formations of new channels, or the deepening of old ones, that it is often difficult, or even impossible, especially in Illinois, to determine the location of the preglacial divides, valleys, and streams.

It has generally been recognized that there was no preglacial Ohio River. There is some positive evidence (Coffey, 1958) that in preglacial time all drainage in Ohio was northward into the Lake Erie basin and also evidence that much of that in Indiana and possibly in Illinois was northward into the Lake Michigan basin. A map of the probable preglacial divides and drainage, based upon an interpretation of the available data, is shown in figure 3. The preglacial drainage in Ohio, indicated on this map, is practically the same as that on the map in my 1958 article (*ibid.*) with a few changes having been made to accord with the later map by Cummings (1959).

Teays and Mahomet Rivers

Probably the most important question regarding the early drainage in Ohio, Indiana, and Illinois is whether the old Teays River in preglacial time flowed northward from Chillicothe through the present broad Scioto Valley into the Lake Erie basin, or whether it turned northwestward in Pickaway County and continued along the old comparatively narrow, abandoned Mahomet Valley across the divide between the present Scioto and Miami Valleys and continued into and then westward across Indiana and southwestward through Illinois to the Mississippi River. If the former represents the true preglacial drainage of the Teays River, then the Mahomet River must have been formed by the blocking of the northward Teays drainage by the advance of an early glaciation, probably the Nebraskan.

The present Scioto Valley, and northward to Lake Erie, is underlain by the Devonian geological formation, which evidently was easily eroded. It would certainly seem more natural for the old Teays River to have extended northward to Lake Erie and to have been primarily responsible for the formation of the broad Scioto Valley rather than to have turned northwestward on what, if true, would have been the divide between the Great Lakes and the Gulf drainage. No other explanation of the origin of this broad upper Scioto Valley, so far as I know, has been offered. Positive evidence on this question is shown on a bedrock surface map by Stout (1943) and on one by Cummins (1959). Leverett (1897: 21) suggested the former as one of the possible courses.

The elevation of the bedrock surface in the broad upper Scioto Valley, as

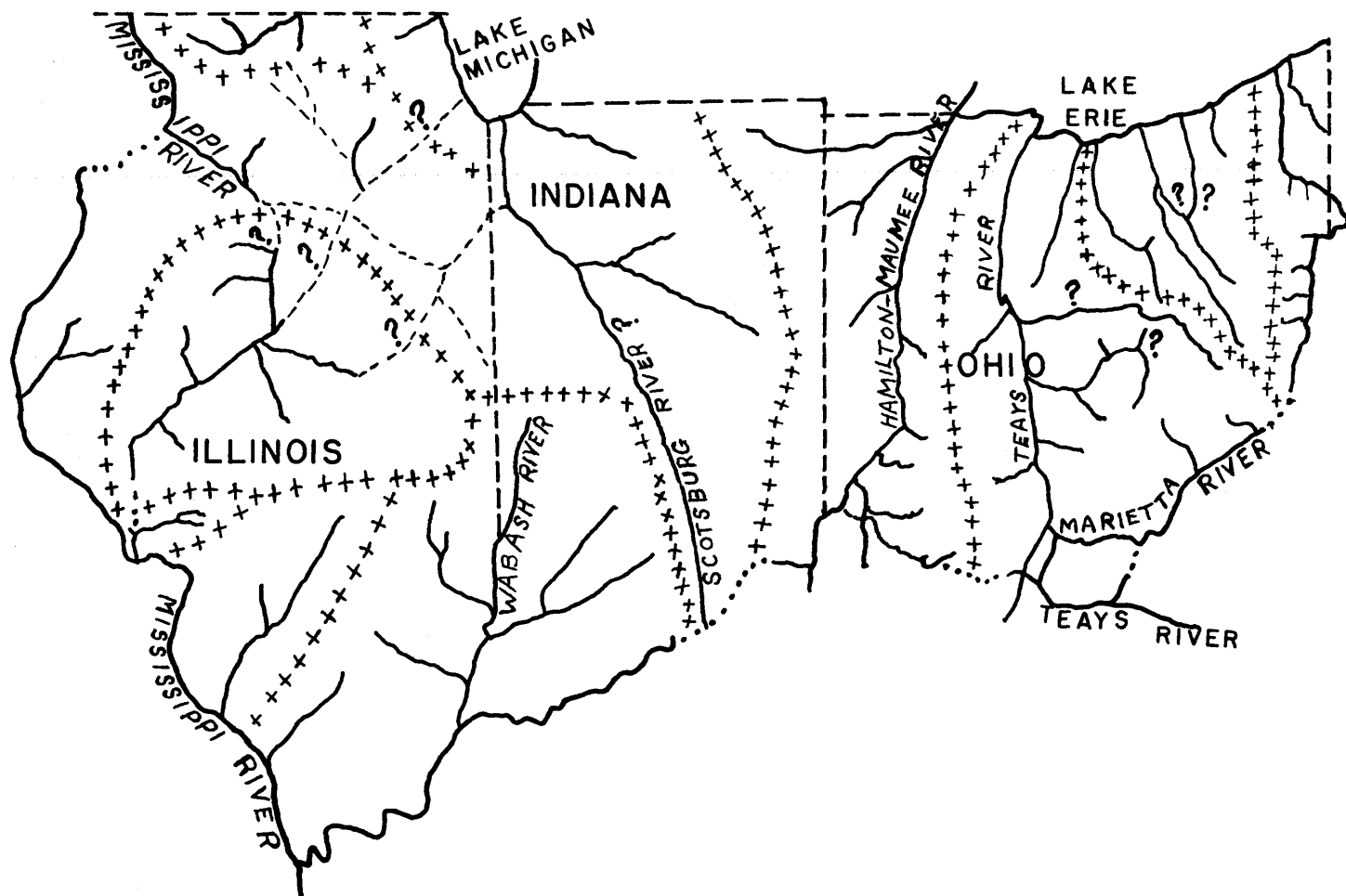


FIGURE 3. Preglacial divides and streams.

indicated on these maps, for a width of more than 30 miles, is less than 1,000 ft and some sections is less than 900 ft, while the hills on each side rise rather abruptly to more than 1,200 ft and in some small areas to more than 1,300 ft. From Logan County, which has the highest present surface elevation of 1,533 ft in the three states included herein, southward along the divide between the Scioto and Miami Valleys almost to the Ohio River, the bedrock elevation is, for practically the entire distance, above 1,000 ft and in some places is more than 1,100 ft, except in Champaign, Clark and Madison Counties where the deep, narrow, abandoned channel of the old Mahomet-Teays River, having a bedrock elevation of less than 600 ft, extends northwestward across the divide and continues across the old Hamilton River valley, where the surface elevation is less than 800 or 900 ft, into Indiana and Illinois, thus forming the old Mahomet River.

The old Mahomet-Teays River continued until the Kansan glaciation advanced southward much beyond the old Mahomet in all three states. This resulted in the deposition of glacial material in all of the old valley and the elimination of this stream, and many other preglacial streams, throughout practically its entire length.

This and other data on the bedrock surface maps furnish positive evidence that the preglacial Teays River, and also the old Hamilton-Maumee River, flowed northward into the Lake Erie basin and that the abandoned channel of the old Mahomet River through Ohio, Indiana and Illinois must have resulted from the later blocking of the northward flow of the old Teays and Hamilton Rivers as well as much of the preglacial drainage in Indiana and Illinois by the advance of an early glaciation, probably the Nebraskan. This advance caused the old Teays River to break over the divide on the west and, during the thousands of years before the coming of the Kansan glaciation, cut out a deep and in some places narrow valley, making it interglacial rather than preglacial in origin. This offers the only logical explanation for the origin of the present broad upper Scioto Valley, as well as for other deep valleys, which is difficult or even impossible to explain otherwise.

Ohio Preglacial Drainage

Geologists generally agree that there was no preglacial Ohio River and that there was a divide in Monroe County from which the drainage flowed northward, joined the old Pittsburgh drainage and continued northward through the present Mahoning and Grand River valleys into the Lake Erie Basin. From this same divide the drainage was southwestward along the present Ohio River valley to about Gallipolis, where it turned westward and northwestward and joined the old Teays River in the present Scioto Valley near Waverly.

The divide in Monroe County extended northward at an elevation of more than 1,200 ft and in Belmont County divided, one section extending northward to near Lake Erie and the other one extending northwestward across the present Tuscarawas Valley near Port Washington and continuing westward through southern Holmes, Ashland, and Richland Counties to eastern Morrow County. The area north of this divide and west of the other one extending north from Belmont County to Lake Erie has been dissected into so many deep connected valleys by the advance of the glaciers, that it is impossible to determine definitely the location of most of the preglacial streams, the drainage of all of which eventually entered the Lake Erie basin. This will be evident from the bedrock surface map by Ver Steeg (1934) which covers a considerable portion of the area.

It is generally agreed that the locations of the present Conotton and Stillwater Creeks are essentially the same as those in preglacial time. The Conotton Creek extended northwestward as far as Clinton in southwestern Summit County, from where it may have continued northward by Akron and along the present Cuyahoga Valley to the Lake Erie basin, or it may have continued northwestward along the

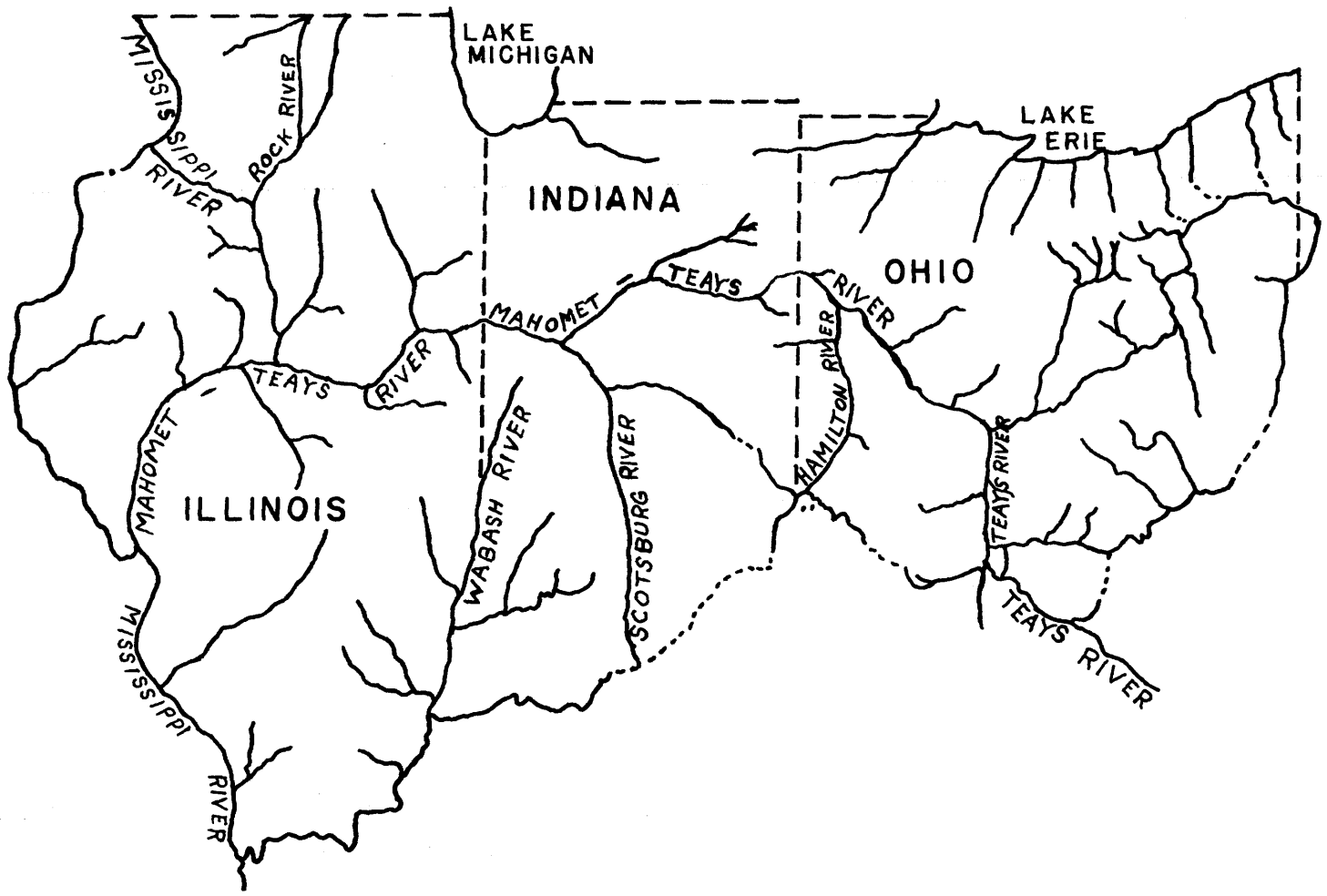


FIGURE 4. Nebraskan drainage.

present Chippewa Valley to near Rittman and there turned northward along the old valley east of Rittman and Medina and along the west branch of the present Rocky River to the Lake Erie basin. The Stillwater Creek evidently continued northwestward into the southwest corner of Stark County, where it may have turned east and joined the Conotton; or more probably it continued northwestward across Wayne County and through the valley in which Chippewa Lake is now located and joined the old Conotton River in northwestern Medina County and continued northward into the Lake Erie basin. As already suggested, the drainage in southeastern and central Ohio was northward along the old Teays River and that in western Ohio was likewise northward along the old Hamilton River into the Lake Erie basin.

Indiana Preglacial Drainage

The location of the preglacial drainage in Indiana, and especially in Illinois, is much more difficult to determine than that for Ohio. Geologists generally have considered the Mahomet River as preglacial and have determined the drainage upon this basis. However, Ver Steeg (1934: 611) refers to the old Teays River and states, "... from Chillicothe northward its most probable course was to the north through the broad lowlands now occupied by the tributaries of the Scioto River in western Ohio." If the preglacial drainage of the old Teays and other streams in Ohio was northward into the Lake Erie basin, as indicated by the evidence already presented, then the old Mahomet River in Indiana and Illinois was interglacial rather than preglacial. No one seems to have been able to identify definitely any Nebraskan glacial deposits in this old valley. This would seem to indicate that it was of Nebraskan origin. The development of the Lake Michigan basin below the bedrock surface, which surrounds its southern extension, would seem to have required the discharge into it by one or more streams draining rather large areas. This basin would probably have been considerably deepened by the glaciers.

As shown on the bedrock surface map in figure 2, most of the southeastern part of Indiana, except a broad valley known as Scottsburgh lowland which extends northwestward from the Ohio River into the northwestern plains, has an elevation of more than 750 ft and in a few small areas of more than 1,000 ft, while in all of the northern and western parts, and also in the broad valley just referred to, it is less than 750 ft. In the Wabash and old Mahomet Valleys and small areas near Lake Michigan, and also in the northeast section, the elevation is less than 500 ft.

This general northwestward slope of most of the bedrock surface, except the southwestern part, is evidence that most of the preglacial drainage was probably into the Lake Michigan or Lake Erie basin. This would include the drainage of the Scottsburgh lowland, which is underlain by the same geological formation (see fig. 1) as the broad Scioto Valley in Ohio. Both valleys extend northward from the present Ohio River into the lake plains and were apparently formed by streams which flowed northward into the lake basins. This Scottsburgh lowland is bordered on the west by the Knobstone escarpment, which, according to Wayne (1956) "... rises 400 to 600 feet above the lowland east of it."

Illinois Preglacial Drainage

The early drainage in much of Illinois is very difficult, or even impossible, to determine. The elevation of the bedrock surface, shown in figure 2, and the probable location of the more important divides, which are indicated on the preglacial map shown in figure 3, are of definite assistance. Much, however, depends on whether the old Mahomet River was preglacial or resulted from the advance of an early glaciation, probably the Nebraskan. Geologists generally have considered it preglacial, but positive evidence that it resulted from the

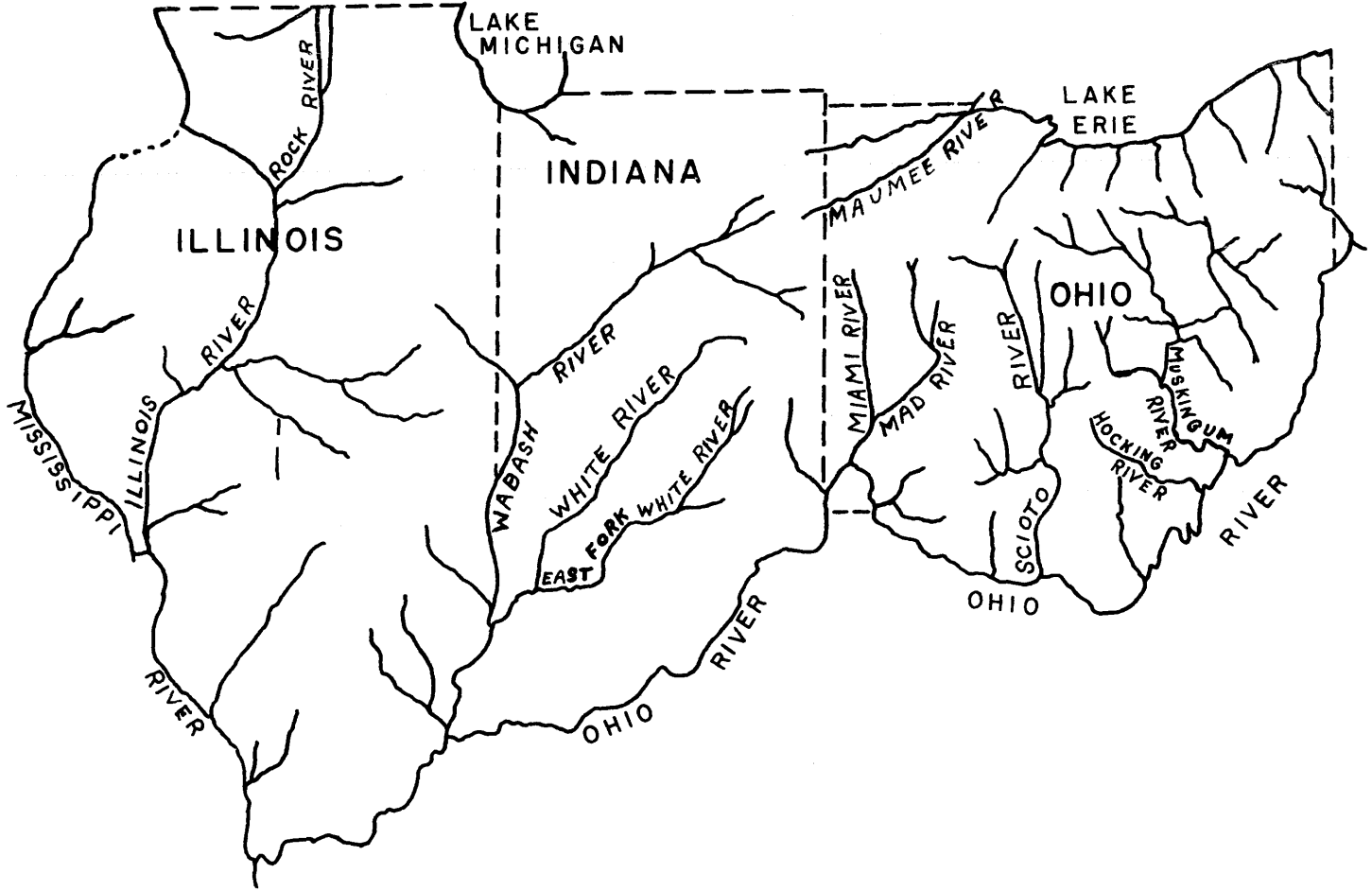


FIGURE 5. Kansan drainage.

advance of an earlier glaciation, probably the Nebraskan, has been previously presented (Coffey, 1930-1958) and in the earlier part of this paper. If the deep valleys in Illinois are interglacial, as the evidence indicates, then the elevation of most of the preglacial bedrock surface in central Illinois may have been 600 ft or more, as indicated by some small areas in this section with an elevation of more than 700 ft.

Practically the entire divide, which extends from Indiana westward across south central Illinois to the Mississippi River, has a bedrock elevation of more than 600 ft, except where it is intersected by the deep comparative narrow valley of the lower Illinois River whose steep bluffs rise to more than 600 ft. The elevation of this divide increases to over 750 ft in the section west of the Illinois River and in a small area in the eastern part.

The present drainage northward from the old divide, except where it is intersected by the lower Illinois River, would seem to indicate that all of the preglacial drainage north of it may possibly have been northward into central Illinois. If this is true, the drainage in the western part was probably northward and then northeastward along the present broadening valley of the Illinois River to central Illinois, where it may have turned southeastward along what later became the old Mahomet Valley and then northeastward and in Iroquois County may have been joined by the northern Illinois drainage and continued into Indiana, where it united with the Indiana drainage and flowed northward into the Lake Michigan basin.

Another possibility, however, is that instead of turning southeastward it continued northward along the present Illinois Valley to Putnam County or northeastward along the valley in western McLean and Livingston counties and in LaSalle County joined the northern Illinois drainage and continued northeastward along an old valley into the Lake Michigan basin. It would probably have been joined in central Illinois by the drainage from the southeast along a section of the later old Mahomet Valley. It is possible also that it may have been joined in Grundy County by the drainage from the southeast toward the Indiana line.

Another possibility, in regard to the drainage north of the divide in south central Illinois, is that from this divide in Vermillion County another preglacial divide probably extended northwestward across what later became the Mahomet Valley in Champaign County and continued northwestward across northeastern McLean and southwestern Livingston counties and across the present Illinois River Valley in Marshall County, in the western part of which, as well as in three small areas in northeastern McLean County, the elevation of the bedrock surface is more than 700 ft. If this truly represents a preglacial divide, then all of the drainage southwest of it and north of the divide in south central Illinois would have been westward and then south along the present Illinois Valley into the Mississippi River; and the drainage north of it would have been eastward into the Lake Michigan basin. The northeastern course of the present Pecatonica River in northwestern Illinois and the angle at which it enters the Rock River may indicate that its preglacial drainage, and possibly that of the upper part of Rock River, may have been northward through Wisconsin into an arm of the old Lake Michigan basin. It may mean also that the Rock River is largely of interglacial origin and that in preglacial time the drainage in the lower section was southeastward to join the old Mississippi River, which may then have flowed northeastward into the Lake Michigan basin or southeastward into Indiana to join the Indiana drainage northward into that basin.

It is, of course, possible that such a preglacial divide did not exist and that all of the preglacial drainage in northern Illinois, except that in the northeastern part which went into the Lake Michigan basin, flowed southward along the present upper Illinois River valley and in the central part was joined by drainage from the east central part and turned southwestward and then south along the present

Illinois Valley, which gradually decreases in width from a broad valley in central Illinois to a comparatively narrow one with steep bluffs before entering the Mississippi River. This could have been true, although the preglacial valleys were evidently greatly deepened and broadened after the advance of an early glaciation and the formation of the Mahomet River.

The possible different preglacial drainages which have been suggested indicate the great difficulty, or even impossibility, of determining definitely the location of even the major preglacial streams in Illinois. The streams, which the evidence seems to indicate as those most probably representing the preglacial drainage, are shown in figure 3. This map represents the preglacial drainage as being prior to the formation of the Mahomet River. Horberg (1950) considers it practically the same as the Nebraskan glacial map in his article.

Advance of the Glaciers

During the Pleistocene Epoch the preglacial and interglacial drainage was greatly changed by the advance of the different glaciations, of which there were at least four, the Nebraskan, Kansan, Illinoian, and Wisconsin. It has been estimated that the Nebraskan glaciation was probably one million or more years ago and that thousands of years intervened between each advance but only the preglacial, Nebraskan and Kansan drainage is being considered in this article.

During the Pleistocene Epoch the ice advanced from the northeast through the Lake Erie Basin and from the north along the Lake Michigan basin and possibly between these two from the Lake Huron basin; and advanced from the northwest in west central Illinois and covered most of the area of the three states, except the southeastern part of Ohio, the southwestern part of Indiana, and the southern and extreme northwestern parts of Illinois. The advance of the different glaciations, especially the earlier ones, produced many major, and numerous minor, changes in the preglacial drainage but it is often difficult, or even impossible, to determine the location of the preglacial and early interglacial streams. "Many changes, especially drainage modifications, are apparent in wide areas, are sufficiently old in point of physiographic history and are difficult to account for on any other assumption than the effect of an early glacier" (Stout and Lamb, 1939).

Nebraskan Glacial Drainage

The generally southwestward, or southward, advance of the Nebraskan glaciation over much of northern Ohio, Indiana, western and possibly northeastern Illinois has been generally accepted, although the materials which were deposited by it have practically all been removed by the advance of the later glaciations; so that it is not possible to determine definitely the southern limit of the area covered by it. In Ohio it was probably halted by the rapid increase in the elevation along the northwestern extension of the Allegheny Plateau. The location of the old Mahomet Valley, which, positive evidence indicates, was brought about by the advance of the Nebraskan glaciation, helps in determining its limits. As the glacier advanced it blocked all northward preglacial drainage into the Lake Erie and Lake Michigan basins and forced the streams to reverse along old channels, or to develop new ones. The principal Nebraskan glacial drainage is shown in figure 4. In Illinois this is practically the same as the preglacial and Nebraskan drainage by Horberg. After the retreat of the glacier much of the drainage in the northern section, especially in Ohio, again flowed northward into the old lake basins.

Ohio Nebraskan Drainage

The advance of the Nebraskan glacier in Ohio and in most of Indiana was from the northeast along the old Lake Erie basin from which it spread southward, tending to flow around the higher areas and to spread out like fans from the larger valleys. Goldthwait has estimated that the advance of the same glacier at fastest

known speed took 5,000 years to cross the state the first time. As the glacier advanced from the northeast it would have blocked the Lake Erie drainage and have resulted in an increase in the level of the lake to an elevation of 600 or 700 ft, when it broke over into Indiana and continued until the glacier advanced to the higher lands on the south.

When the ice advanced south far enough to encounter the northern end of the divide, which extends north from the Ohio River in Monroe County to Geauga County and forms the western boundary of the Grand River Basin, it blocked the northward Pittsburgh and northeastern Ohio drainage and formed a lake, which continued to rise and back up until it reached the lowest elevation in the old divide along its western border, which was probably at least 1,100 ft, and broke over just south of Ravenna (Coffey, 1914, 1930). The drainage may have flowed northward along the old Ravenna River (Scranton and Lamb, 1932), and later joined the drainage in the old Cuyahoga Valley and continued northward into the glacial lake which had risen until it overflowed into Indiana at an elevation probably around 650 ft. As the glacier continued southwestward very slowly, it would have gradually blocked any northward drainage and after probably more than 1,000 years would have included that of the old Cuyahoga Valley and also that of the old Grand River valley, which had broken over the divide near Ravenna.

The changes in the drainage in the present Cuyahoga and upper Tuscarawas drainage basins have probably been greater and the valleys more deeply eroded than those in any other section of Ohio, as may be seen from the map by Ver Steeg (1934). In the Cuyahoga Valley about 15 miles east of Independence Ver Steeg (1938) secured data showing, ". . . the floor of this valley lies 13 feet below sea level." According to Winslow, White, and Webber (1953), ". . . well records in Cuyahoga River Valley indicate the valley floor to be 100 feet or more below sea level near Gordon Park at the Lake Shore." In the Chippewa Valley in northeastern Wayne County borings showed the depth to the rock surface to be as much as 417 and 443 ft, or approximately 50 ft below the level of Lake Erie. The formation of these and other deep valleys may indicate a rise of the land and erosion by the streams or glaciers, or by both.

As the ice came from the northeast, it would have advanced along the old Cuyahoga Valley before reaching the areas west; and this would have blocked not only the drainage in the old Cuyahoga Valley but also the Pittsburgh drainage, which had broken over the divide near Ravenna. This may have resulted in turning the Pittsburgh drainage southwestward and in the formation of an old valley from near Ravenna by Fitch and Portage Lakes into the present Tuscarawas Valley, as suggested personally by Lamb.

The blocking of the northward drainage had resulted in the formation of a lake, which continued to rise and advance southward until it reached the preglacial Tuscarawas drainage and joined with it. Then it turned northwestward along the present Chippewa Creek in northeastern Wayne County and continued northwestward along an old stream east of Rittman and Medina and was probably principally responsible for the deep erosion that resulted.

As the glacier moved slowly southwestward, it would have blocked this stream and successively have joined and then blocked other streams, which formed the old valleys shown on the map by Ver Steeg (1934), until the glacier had moved far enough southwest to block all of the streams and result in their reversal, or in the formation of other streams, which flowed southward and became part of the present Tuscarawas drainage system, or formed the Mt. Vernon River as described by Dove (1960), which may have extended southwestward from Wayne county by Perrysville and Mt. Veronon to join the Cambridge River in northwestern Fairfield county, and then continued and joined the Teays River in Pickaway county. It is possible, of course, that some of these changes were brought about

by later glaciations, especially the Kansan, but the evidence indicates that the most important changes in northern Ohio resulted from the advance of the Nebraskan glaciation.

As the glacier had blocked all northward drainage in this section, the lake continued to rise along the old Conotton, now the Tuscarawas Valley, until near Brewster it broke over the divide between the old Conotton and Stillwater valleys and followed the latter to beyond New Philadelphia. Continuing to rise, the lake extended southwestward until it reached an elevation of 1,100 or 1,200 ft and near Port Washington it broke over the divide, which extends northwestward from Monroe County, and cut out a wide gorge now occupied by the Tuscarawas River. The present Tuscarawas Valley through this old divide is approximately twice as wide as the present Ohio Valley. If, as the evidence indicates, the drainage that broke over this divide included the Pittsburgh and eastern Ohio drainage, as well as that of most of northeastern Ohio, which had formed a large lake, the formation of this unusually wide valley would apparently be explained. The stream thus formed flowed southwestward and then westward and was joined by a stream from the southeast and continued by Coshocton and probably Newark, and joined the old Teays drainage in the old Scioto Valley.

Since it has been estimated that the advance of the glacier southwestward across Ohio probably took 5,000 years, it is possible that it had not yet reached the upper Scioto Valley and that the drainage along this valley was still northward into glacial Lake Erie, until the glacier had moved far enough south to encounter the highlands in Logan County and thus to block all northward drainage along what is now the Upper Scioto Valley.

The drainage thus blocked would have included not only all that of the old Teays River in southeastern Ohio, much of West Virginia and eastern Kentucky, smaller amounts from Virginia and North Carolina west of the Blue Ridge Mountains, but also that from northeastern Ohio and western Pennsylvania, as already outlined.

The blocking of the drainage in the old Teays Valley would have resulted in the formation of a glacial lake, which would have risen and backed up the drainage along the other valleys for many miles until it reached the lowest points in the divide along the west side of the old Teays Valley, which was apparently in Madison, Clark, and Champaign Counties, where it broke over and continued northwestward, was joined by the old Hamilton drainage, the north part of which was blocked by the glacier, and was forced to turn west and enter Indiana. Some of the silts along the old Teays River and its tributaries were probably deposited during this backing up of the drainage by the Nebraskan glaciation, but later deposits were doubtless made during the Kansan glaciation.

Indiana and Illinois Nebraskan Drainage

The advance of the ice southwestward along the Lake Erie basin and south along the Lake Michigan Basin forced all drainage in Indiana and Illinois, which had been northward or northeastward into these basins, to join that from Ohio and thus to form what is known as the Mahomet, or Mahomet-Teays River. This Mahomet River represented an extension of the old Teays River from the old Scioto Valley in Ohio, northwestward across western Ohio, and westward across Indiana and westward to central Illinois, where it united with the old Mississippi drainage and formed the present Illinois River.

Since this old Mahomet River would have included not only the drainage of the old Teays River and other streams which had been forced to join it, but also the Hamilton River in western Ohio and all streams in northern and central Indiana and Illinois, including the old upper Mississippi River, it must have been a large stream, which, during the thousands of years that intervened before the Kansan glaciation reached this section, would have eroded a deep valley, much of which has been largely filled by the Kansan and later glaciations.

After the retreat of the Nebraskan glaciation, much of the drainage in northern Ohio and northeastern Indiana apparently returned to the Lake Erie basin; but very little of that in Indiana and Illinois returned to the Lake Michigan basin. Most of it continued along the old Mahomet River. It is possible that the old Pittsburgh drainage continued across the divide south of Ravenna until the advance of the Kansan glaciation, but it may have resumed its preglacial channel northward through the Grand River valley into the Lake Erie basin.

Kansan Glacial Drainage

The Kansan glaciation advanced principally from the northeast and north, except in west central Illinois where it came from the northwest. It extended much farther south than the Nebraskan. Both the Lake Erie and Lake Michigan sections moved southward until they blocked all northward drainage, especially that of the old Mahomet-Teays River and its numerous tributaries, which included most of the drainage in the three states being considered. This blocking of the drainage resulted in the elimination of the Mahomet River, the reversal of many streams and in the formation of new ones, including the present Ohio River, and in the deepening of many old valleys. Evidence indicates that the old Mississippi River was not materially affected but that it continued to flow southward through most of the present valley of the Illinois River.

The drainage which developed in the deep interglacial valleys has been referred to as "Deep Stage" by Stout and Lamb (1939: 22). Since the advance of the Kansan glaciation apparently blocked most of the drainage and at least partially filled some of the deep valleys, like the Mahomet, with glacial deposits, deepened some of the old valleys, like the present Scioto and Miami, and also formed new ones, like the Ohio, the "Deep Stage" should probably be divided into two stages, the Nebraskan, or Mahomet River stage and the Kansan, or Ohio River stage.

Formation of the Ohio River

The advance of the Kansan glaciation apparently first blocked the old Pittsburgh and eastern Ohio drainage in the present Grand River Valley. This resulted in the formation of a lake which rose until it broke over the divide in Monroe County and joined the southwestward flowing stream. Continuing southwestward and uniting with the old Teays River, it continued along this old stream westward and then northwestward to near Wheelersburg, thus forming this section of the present Ohio River, which eventually became the southeastern boundary of Ohio.

The advance of the Kansan glaciation southwestward, by blocking the drainage in the old Teays Valley, resulted in the formation of a lake which rose until it broke over the divide west of Wheelersburg and continued westward by Portsmouth. There it broke over the old divide in southern Adams County and continued northwestward to near Cincinnati, thereby forming most of the southwestern section of the present Ohio River. Near Cincinnati it joined the old Little Miami River, then turned west by Norwood where it joined the old Licking River and, continuing northwestward to south of Hamilton, it joined the old reversed Hamilton River, now the Miami River, and followed it beyond where the present Ohio River joins it. The section of the Ohio River south of Cincinnati was apparently formed by the later Illinoian glaciation.

The Hamilton section of the new Ohio River continued southwestward and broke over the divide near Madison, Indiana, and then continued until it reached the Scottsburgh lowland, which, as already pointed out, has an escarpment along its western border (Wayne, 1956) that rises 400 to 600 ft above the lowland east of it; and near the Ohio River west of New Albany it has the largest area in Indiana where the elevation of the bedrock surface is more than 1,000 ft (fig. 2). Since

this escarpment would evidently have blocked the new Ohio River drainage, it apparently turned northward into the Scottsborough lowland where, in the southern part as will be explained later, it probably remained until the advance of the Illinoian glaciation forced it to break over the escarpment southwest of New Albany. Then it continued southwestward to the Mississippi River, thereby forming the present southern boundary of Indiana and Illinois. The elevation of the bedrock surface of the Mississippi River at this junction is less than 200 ft above sea level.

Ohio Kansas Drainage

The advance of the Kansas glaciation southward possibly caused more important changes in the drainage in Ohio than that of any other glaciation. It blocked all northward drainage into the Lake Erie basin and also that of the old Mahomet-Teays River and its many tributaries.

Attention has already been called to the blocking of the old Pittsburgh and eastern Ohio drainage and its breaking over the divide in Monroe County. That the breakover of this divide in Monroe County was later than that over the divide near Port Washington in Tuscarawas County is evidenced by the difference in the pattern of the contours east and west of the divide, which separates the drainage between the Ohio and Tuscarawas Rivers, sometimes referred to as the Flushing Escarpment. According to Stout and Lamb (1939: 5), "The pattern east of the escarpment in this respect lacks the deep indentations of that to the west. Thus the surface east of the escarpment in contrast to that to the west, has wider ridges, less direct relief, fewer small streams, and in general more uniformity." This difference in surface conditions furnishes positive evidence that the breakover of the divide near Port Washington by the Tuscarawas River was during an early glaciation, probably the Nebraskan, while that of the divide along the present Ohio River in Monroe County was during a later glaciation, probably the Kansan.

Although the present Tuscarawas River continues southwestward through the old divide near Port Washington, according to Ver Steeg (1934: 613), "... the bedrock slope of the buried valley of this stream is to the north," and has been termed the Cleveland River by Stout and Lamb (1939: 25). This seems to indicate that, following the retreat of the earlier glaciations, the Tuscarawas drainage east of this divide was again northward and contributed to the formation of the deep bedrock valleys in this northeast section of Ohio.

Evidence indicates that the advance of the Kansan glaciation was far enough southeastward to have blocked the old Tuscarawas River, possibly in Licking County, and resulted in the break over of the col near the Muskingum-Morgan county line and in the formation of the present Muskingum River; also, that it blocked other westward drainage and resulted in the formation of the present Hocking River and other smaller streams.

Hubbard (1954) states, the "... col at Blue Rock was before the Illinoian glacier came, and was probably initiated by the Kansan or Nebraskan ice sheet." He also states, "... there are terraces on the Muskingum of at least three ages, Wisconsin, Illinoian, and an older stage probably Kansan" and also the findings "... established the Hocking streams adjustments as pre-Illinoian." These terraces are above the present flood-plain terraces. The diversion of water over the col below Blue Rock must have been early enough to have enabled the new through stream to carry Kansan outwash and lay it along the valley.

In *What the Glaciers Did to Ohio*, Goldthwait estimated "... this creeping sea of ice must have ground over Ohio slowly too; at fastest known speed it took 5,000 years, just to cross the state the first time." It would seem, therefore, that possibly the section of the new Ohio River east of Wheelersburg was formed a thousand or more years before the glacier, probably the Kansan, blocked the old Mahomet-Teays River in western Ohio, and that the newly formed Ohio River

continued northward along the old Mahomet-Teays River until this stream was blocked by the advance of the Kansan glacier, which was probably first in the old Hamilton valley in western Ohio, as indicated by the location of the moraines and by the Mahomet-Teays River being much farther north in the old Hamilton valley in western Ohio than in the Scioto valley. As the glacier moved farther southward, it would have resulted in the backing up of the drainage in the old Mahomet-Teays River until it probably broke over in Clarke County and formed the present Mad River which flowed southward and joined the old reversed Hamilton River. This may have formed the Ohio River west of Cincinnati before the advance of the ice farther southward forced a breakover west of Wheelersburg and Portsmouth which extended westward and united with the old Hamilton River north of Cincinnati.

The blocking of the old Teays drainage would have resulted in the formation of a lake, or lakes, which would rise until they broke over the divides on the west to form the present Ohio River, except south of Cincinnati, which was formed later. Since this new Ohio River was a large stream, it would have rather rapidly lowered its channel, thereby, making it possible for the streams in the old Hamilton and Teays valleys to be reversed and form the present Scioto and Miami Rivers, and gradually lowering the surface in these valleys so that it now slopes toward the south instead of toward the north as was previously the case.

The backing up of the drainage in the old Teays valley made possible the deposition of the silts in this old valley and its tributaries. Some of the materials in these silts came from as far south as North Carolina, having been transported northward by the old Teays River, now the New River, which rises near the crest of the Blue Ridge Mountains, about 2 miles northeast of Blowing Rock. Since the present Yadkin River rises just east of the crest, within approximately a half mile of the New River, and rapidly descends 1500 or 2000 ft before entering the Piedmont Plateau, it does not seem possible that the old Teays River "gathered its headwaters out in the Piedmont Plateau" as has been suggested in several articles by different authors, or that "the high content of sericitic mica indicates that the Minford silts were derived largely from the schists of the Piedmont and therefore the streams headed well out on this old highland," as stated by Stout and Lamb (1938), since this could have come from the gneisses and schists which, according to the geological report and map of North Carolina by Stuckey and Steel (1953), "... underlie much of the Blue Ridge Mountains ..." and in fact practically all of the western part of the state.

Indiana Kansan Drainage

The Kansan glaciation in Indiana extended southward and covered practically all of the northern and central part of the state, evidenced by the presence of deposits definitely determined to be of that age (Wayne, 1956). These deposits are formed in many sections, including the Mahomet Valley, but no deposits of Nebraskan age have been found there.

The drainage in the old Mahomet River in Indiana was probably blocked first in the western part of the state by the advance southward of the Lake Michigan lobe of the Kansan glaciation. This may have been before or after the advance northward of the new Ohio River drainage along the Scottsburgh lowland. The blocking of the Mahomet drainage would have resulted in its backing up until it probably broke over the divide on the south near the Illinois line and joined the old Wabash River and continued southward along this old stream into what probably later became the Ohio River. After the retreat of the glacier, it apparently received most of the drainage in northern Indiana, now included in the upper Wabash basin and some of the drainage in east central Illinois.

The new Ohio River drainage apparently continued northward along the Scottsburgh lowland, which has an elevation of 600 to 700 ft, until it was blocked

by the southward advance of the Kansan glaciation, which had formed a lake that rose until it broke over the knobstone escarpment on the west and apparently formed the present White River, which has a narrow valley through the escarpment. As the glacier continued southward beyond this breakover, the lake rose and broke over the escarpment a second time and formed the East Fork of the White River. This offers an explanation of the present peculiar extension of these streams across the Scottsborough lowland and their breaking through the high escarpment along its western border, which is difficult to explain otherwise.

It is possible that the Ohio River drainage continued through the latter breakover until it was blocked by the Illinoian glaciation; and then it broke over the divide near New Albany and continued southwestward to the Mississippi River. If true, it would help explain the uniting of the present drainage from the north and east just west of a small remnant of the escarpment, and the formation of a rather wide deep valley through the escarpment (fig. 2) and in the area to the west, which is still occupied by the East Fork of the White River. It might also explain why there is very little drainage from this lowland into the present Ohio River (Wayne, 1956: 27).

Illinois Kansan Drainage

The Kansan glaciation in Illinois advanced from both the northeast and the northwest and covered most of the state of Illinois, except the southern and northwestern sections. According to Horberg (1950), the north eastern Labradorian, or Lake Michigan lobe, extended southwestward practically to the present Rock, Illinois, and old Mississippi Rivers, and southward as far as a line extending southwestward across the state from Crawford to Randolph County. The Keewatin lobe entered the state from the northwest and covered practically all of the section west of the present Illinois River. The meeting of the two advances from different directions followed rather closely that of the old Mississippi River and apparently produced no major changes in its drainage unless it be in eastern Tazewell County, where it may have blocked the old Mississippi River, resulting in the formation of the present Illinois River along the western boundary of this county.

The most important change in the drainage in Illinois which resulted from the advance of the Kansan glaciation was the blocking of the Mahomet River and its tributaries, which included most of the drainage in east central Illinois. According to Foster and Buhle (1951), "... it appears likely that the Kansan drift completely filled the deep channel of the Mahomet Valley and most of the Havanna strath. Kansan thicknesses probably range from zero to a maximum of 25 ft over the lowest bedrock elevations west of Champaign." They also state, "... no deposits suggesting Nebraskan origin have been discovered in the strath area west of Champaign." If the Mahomet River were formed by the advance of the Nebraskan glaciation, as suggested, there would have been no glacial deposits of this age in this old valley. This absence of Nebraskan deposits tends to confirm the suggestion that the Mahomet Valley was interglacial rather than preglacial in origin. Some of the smaller streams in east central Illinois, which now join the Wabash River, as well as in other sections of the state, were probably formed by the advance of the Kansan glaciation, or possibly by later glaciations.

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